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# Long-term Trajectories of Academic Performance in the Context of Social Disparities: Longitudinal Findings from Switzerland

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## Abstract

This study used a stratified random sample of classes in Zurich, Switzerland, comprising approximately 2,000 students whose academic performances in math and language were assessed across primary and lower secondary education. Based on this longitudinal data, the study investigated the association of social inequalities with the baseline of and gains in academic performance. The study focused on growing social disparities in academic performance during compulsory education, taking into account disparities in the social backgrounds of students as well as in social deprivation of school attendance areas. The results of a multilevel growth curve analysis implemented to model academic performance development at student and school district levels suggest cumulative disadvantages for students from lower socio-economic backgrounds. These students (i) start school with lower initial knowledge and (ii) experience lower improvements in academic performance. The findings also suggest that more advantaged school attendance areas achieved higher average performance levels in the early stages of primary education despite controlling for student socioeconomic backgrounds. On average, however, this gap in academic performance between more advantaged and more deprived attendance areas did not appear to widen over the subsequent years of compulsory schooling.



*Keywords*: compulsory education, long-term academic performance, social disparities, cumulative disadvantage, multilevel growth modeling

**Educational Impact and Implication Statement**

A student's socioeconomic background is key for her academic performance development not only because it determines her initial knowledge at school entry, but also because it further determines what he or she will gain throughout compulsory education that is independent of her initial knowledge. Children of higher socioeconomic backgrounds start at higher levels and benefit more than their less fortunate peers. The school district, in terms of its social deprivation, further seems to impact academic performance in early elementary education, although it has no additional impact beyond students' own social backgrounds on their later academic performance development.

## Background

In contemporary societies, education has become of utmost importance for favorable labor market prospects and is, hence, decisive for economic and social positioning within society; in addition, education relates to health outcomes and subjective well-being, and may even connect to longevity (e.g., Arendt, 2005; Oreopoulos & Salvanes, 2011; Gottfredson & Deary, 2004). Early childhood education has a long-lasting impact on children's development (e.g., Campbell et al., 2008; Ramey et al., 2000). However, education is unequally distributed across societal groups (e.g., Bourdieu, 1971; Jungbauer-Gans, 2004; OECD, 2004, 2016; Sirin, 2005). Social inequalities in education have been the focus of longstanding sociological research (e.g., Solga & Becker, 2012), which has unmasked the meritocratic ideology as concealing the transmission of advantage among the advantaged (Bourdieu, 1971). There are clear social disparities in educational attainment, relating first and foremost to family socioeconomic status (SES) as well as to socially stratified learning environments in schools and neighborhoods (e.g., Coleman, 1968; Gibbons, 2002). Both intra- and extra-familial social disparities shape educational careers and have thus been the focus of a considerable amount of research (e.g., Bradley & Corwyn, 2002; Coleman et al., 1966; Ewijk & Sleegers, 2010; Galster, 2012; Jencks & Mayer, 1990; OECD, 2004, 2016; Rumberger & Palardy, 2005; Sirin, 2005; White, 1982). This study complements existing research on intra- and extra-familial social effects on academic performance development and possesses a unique strength regarding the long-term focus on the evolvement of the effects of social disparities on academic performance—at the individual and school district levels—throughout the mandatory school period.

**Effects of the Family SES**

There is ample evidence that parents' SES correlates with educational achievement of their offspring (OECD, 2004, 2016), leading to the intergenerational reproduction of social disparities in educational careers and related outcomes (Bourdieu, 1971). Social gradients are already found in young children's brain development (e.g., Hackman & Farah, 2009). Through explaining the social disparities in cognitive development and related educational achievement, the literature has identified both biological and environmental contributions.

Based on a genetically informed study design, Krapohl and Plomin (2016) found the link between family SES and children's educational achievement to be genetically mediated. Belsky et al. (2018) show that this connection between genetics and social class is not a spurious correlate of a privileged social inheritance with advantage being purely socially transmitted; rather, their results suggest that genetics can have effects on social mobility in their own rights. The association between genetics and educational achievement is furthermore not merely explained by differences in intelligence; other traits such as personality or self-efficacy are also highly relevant for educational achievement and simultaneously possess a strong heritability component (Krapohl et al., 2014). Genetic influences can yet differ and change across developmental and environmental contexts and thus may be seen as dynamic in nature. Heritability of cognitive ability has been found to increase with age, while complex gene–environment interactions can alter heritability depending upon environmental exposure, opportunities, and constraints (Haworth & Davis, 2014; Shanahan & Hofer, 2005; Belsky et al., 2018).

Sociological (see, e.g., Bourdieu, 1971; Boudon, 1974) and psychological perspectives (see, e.g., White, 1982) mainly focus on the environmental processes that underlie the effects of the familial SES on children's educational achievements. In this vein, parents' SES relates to socially stratified language and interaction cultures that foster, explicitly and implicitly, differentially stimulating learning environments that, in turn, lay the foundations for the cognitive development of their offspring (e.g., Aikens & Barbarin, 2008). Educational expectations, values, and aspirations are transmitted from parents to their children, reinforcing social disparities in the educational effort, self-regulation strategies, participation, and, hence, the next generation's success (e.g., Becker, 2013). SES effects on academic performance may also partly be explained by socially stratified parental school involvement (Cucchiara & Horvat, 2009; Fan & Chen, 2001; Li & Fischer, 2017). Low-SES parents may be under more stress due to, for example, unstable employment conditions or economic hardships. These circumstances can affect their emotional states, undermine long-term goal setting, and make the providing of responsive and stimulating care for their offspring more difficult. Hampered cognitive and socioemotional development of children coupled with maladaptive behavior preventing learning in school may be the result (e.g., Bradley & Corwyn, 2002). Furthermore, parents' economic resources (linked to their educational backgrounds) also play a role in enabling or constraining the range of facilities and leisure activities that can support educational achievement, leading, for example, to widening social gradients in academic performance during the summer break (e.g., Downey, van Hippel, & Bohr, 2004). Against this backdrop, Boudon (1974) distinguishes between *primary and secondary effects of social background* on educational achievement. While primary effects comprise the direct influence of social background on academic performance development, secondary effects encompass socially stratified educational choices and navigations of educational careers, which are further consolidated by socially selective teacher evaluations and support (Bradley & Corwyn, 2002; Maaz & Nagy, 2009). These effects work concomitantly and result in social disparities in educational achievement and careers.

Most empirical studies that focus on effects of the socioeconomic background on educational achievement are cross-sectional (e.g., Jungbauer-Gans, 2004; OECD, 2004; Sirin, 2005; White, 1982), showing that socioeconomic status explains performance differences at one or several points in time. Socioeconomic gradients in education-relevant knowledge already exist prior to children starting school (e.g., Aikens & Barbarin, 2008). Based on cross-sectional evidence, however, it remains unclear whether achievement gaps in later grades may be partly or even fully traced back to achievement gaps that exist before children are enrolled in school. Only more recently, as longitudinal data on educational measurements has become more broadly available, effects of parents' SES on the evolvement of academic performance have received increased attention (see, e.g., Stumm 2017). This study contributes to this more recent research from an international perspective. The question here is whether these initial gaps persist, whether they widen across years of schooling, or whether schools are able to close them at least to some degree and hence compensate the disparities that accompany children from their homes. Taking a longitudinal perspective using vertically-linked scale scores, this paper sheds light on social disparities in academic performance development over the entire span of compulsory education in Switzerland.

Summarizing the empirical evidence on socioeconomic disparities in performance gains, we may note that there is some controversy concerning the direction of the SES effect on performance development (Kieffer, 2012). Based on meta-analytic cross-sectional data, White (1982), for example, found the student-level correlation between SES and educational achievement to be higher in earlier compared to later grades, whereas Sirin (2005) reports stronger correlations in later compared to earlier grades. The more recent research aims toward widening socioeconomic achievement gaps. Stumm and Plomin (2015) are a rare example in that they investigated the long-term developmental relationship between intelligence and socioeconomic status from infancy through late adolescence in the U.K. Their study shows that social disparities in intelligence are magnified throughout childhood and adolescence (Stumm & Plomin, 2015) as are social disparities in teachers' evaluations

(Stumm, 2017). Focusing on social disparities in academic performance from kindergarten through the eighth grade in a U.S. sample, Cameron, Grimm, Steele, Castro-Schilo, and Grissmer (2015) as well as Kieffer (2012) found widening socioeconomic achievement gaps, which has also been identified in Canadian students between the ages of seven and fifteen years (Caro, McDonald, & Willms, 2009). However, Kieffer (2012) reports some change in direction in which widening socioeconomic gaps mainly surface by the third grade. Drawing on the data from the Zurich Learning Progress study and focusing on primary education in Switzerland, widening socioeconomic discrepancies have been documented from the third through sixth grades by Angelone and Ramseier (2012). In line with this previous research, we expect to find widening social gradients in standardized performance measures for both math and reading domains across the entire span of compulsory education in Switzerland despite controlling for initial knowledge.

**Effects of Extra-Familial Social Disparities**

In addition to beneficial resources emanating from the family background, more distal social contexts, such as *schools and neighborhoods*, are also discussed in the literature as influencing educational achievement. Following lines of social stratification, children are part of different social contexts of learning environments depending upon where they live. These differential social learning environments may, over and above their own social backgrounds, affect their cognitive development (Baumert, Trautwein, & Artelt, 2003; Becker, 2013). In turn, effects of the family social background may also partly reflect social segregation in extra-familial learning environments.

Schools arguably represent the most important developmental context for children and adolescents outside their families, where they spend a considerable amount of their waking time and have routine contact with their peers. Focusing on the impact of the socioeconomic composition of schools, Coleman’s prominent study (1966; see also Coleman et al., 1968) suggests that children's achievement is linked to the socioeconomic backgrounds of other students with whom they attend school. Children and adolescents benefit from attending class in schools of high average socioeconomic status (e.g., Kahlenberg, 2002). The Program for International Student Assessment (PISA) studies have shown the effects of schools' social composition on academic performance that exist in many countries, thus raising political and public awareness of compositional school effects (OECD, 2004). Explanations for school composition effects encompass, for example, peer–group spill-over in values, aspirations, and behaviors, which may either support or prevent learning in school. It is assumed that larger shares of students from privileged backgrounds positively foster a pro-school normative environment among peers, resulting in an academically beneficial disciplinary climate that supports higher performance gains. As a further explanation for composition-dependent school effectiveness, it has been argued that teachers adapt the level of demands and instructional practices on the basis of student intake characteristics, which may unequally promote academic performance development (see, e.g., Aikens & Barbarin, 2008; Ewijk & Sleeger, 2010; Thrupp, Lauder, & Robinson, 2002; Thrupp, 1999). Across socially privileged and disadvantaged school attendance areas, parents' expectations, social networks, and school involvement (Cucchiara & Horvat, 2009; Jencks & Mayer, 1990; Li & Fischer, 2017) may also differ, which may additionally result in differential school standards and, consequently, achievement outcomes. Based on academic performance, which is correlated with students' socioeconomic backgrounds, students may be further institutionally separated in different educational *tracks* or *skill-based groups* (Condron, 2008). The resulting increased homogenization in the composition of the student body in different tracks or skill-groups as well as the associated curriculum differentiation can further exacerbate differential learning conditions and gains (see, e.g., Baumert et al., 2003; Condron, 2008; Neumann et al., 2007;

Ophuysen & Wendt, 2009), presumably exacerbating social disparities in educational achievement.

In many countries, children attend school nearby their homes such that schools may be seen as local institutions within neighborhoods. In this case, the social composition of neighborhoods is mirrored in the student intake characteristics of schools. In parallel to effects of school socioeconomic composition on academic performance development, peer–group socialization processes also occur at the neighborhood level outside the school (Ainsworth, 2002; Galster, 2012; Jencks & Mayer, 1990). Therefore, contextual effects at the level of neighborhoods and schools are often intertwined, and schools may be pathways through which the influence of the social composition of the neighborhood on educational outcomes is transmitted (Sykes & Musterd, 2011; Kauppinen, 2008). Several studies have illustrated the effects of the social composition of neighborhoods on outcomes such as educational attainment, attitudes toward schooling, anti-social behavior, criminality, and health (e.g., Ainsworth, 2002; Case & Katz, 1991; Garner & Raudenbush, 1991; Gibbons, 2002; Gibbons, Olmo, & Weinhardt, 2013; Kling, Liebman, & Katz, 2007; O'Campo et al., 2015). The magnitude and existence of neighborhood effects are, however, not devoid of controversy (e.g., Gibbons et al., 2013; Nieuwenhuis, 2016).

In sum, disadvantageous or advantageous effects of familial social backgrounds on academic performance development may partly be the result of segregation into more or less beneficial extra-familial learning environments. This study therefore addresses the longitudinal effects of familial social status on academic performance development in the context of the social deprivation of school districts.

Aikens and Barbarin (2008) investigated contextual effects on the development of reading skills between kindergarten and the first few elementary grades based on a U.S. sample. Their results suggest that school and neighborhood contexts start to matter when children begin attending school. Initial reading in kindergarten is more closely related to family background than extra-familial environments. The socioeconomic composition of schools has also been proven to influence academic performance gains during primary and lower secondary education (e.g., Kieffer, 2012) up to the high school level (see, e.g., Rumberger & Palardy, 2005).

## Research Questions

The Zurich Learning Progress Study assessed the language and math performances of a stratified random sample of first grade students in a continuing and standardized fashion during their primary and lower secondary education. The unique longitudinal data of this study enabled an investigation of initial knowledge as well as improvement in academic performance during compulsory education in the Canton of Zurich, Switzerland. Using this longitudinal and standardized data on students' initial knowledge and gains in academic performance, the present study sets forth to tackle the following research questions:

i) Is there a significant difference in initial knowledge across first grade students of differential socioeconomic standing?

ii) Is there a widening gap in academic performance during compulsory education across lines of social stratification despite controlling for initial knowledge?

iii) Are students attending school in socially more deprived school attendance areas disadvantaged in their academic performance development?

We employed a multilevel latent growth curve modeling of the math and language performances of students to investigate inter-individual as well as inter-school district-level differences in academic performance. First, we evaluated intra-individual differences in academic performance in the domains of language and math over primary and lower secondary education. Second, inter-individual differences in language and math performance were examined in relation to individual-level social background characteristics and initial knowledge. Finally, we investigated whether or not the context of school districts affected academic performance over and above the initial knowledge and social background characteristics of students. In this regard, we tested whether social deprivation across the school attendance areas predicts underachievement over the span of compulsory education.

# Method

## The Present Study in the Educational Context of Switzerland

In Switzerland, compulsory education is decentralized and regulated at the cantonal level. In most cantons, primary education encompasses six years of schooling, starting at age six, while lower secondary education comprises another three years of schooling. Both primary and lower secondary education are mandatory for all children and youths in Switzerland. A prominent characteristic of Switzerland's education system (in accordance with that of Germany and Austria) is early tracking. In lower secondary education, students are separated into different school tracks of differential cognitive demand, which open up disparate prospects for future careers.[1] The highest-level track of lower secondary education, when followed up in upper secondary education, allows for direct entry into universities in Switzerland.[2] Other lower secondary education tracks more frequently result in vocational education careers. Another characteristic of Switzerland regarding its upper secondary education system is its predominant vocational orientation. About two-thirds of youth cohorts pursue vocational education at the upper secondary level (see, e.g., SKBF, 2014). The Canton

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[1] Different models of tracking exist across and even within cantons. Students pursuing lower secondary education may be separated into completely different classrooms according to the level of demand of the school type they pursue, or they can be taught in integrated classrooms with level-based courses. For the Canton of Zurich, the model of separating students in lower secondary education in different school types remains dominant.

[2] In some cantons (including Zurich), access to the academic track at the lower secondary and/or at the upper secondary level requires passing an exam upon completion of primary or lower secondary education.

of Zurich, from which the sample of this study was drawn, comprises the largest share of Switzerland's student population. Zurich stands out as a canton with strongly limited admission to the academic track at lower and upper secondary-level education compared to the demand side of many highly educated parents. This proposes a highly interesting setting for studying competition regarding scarce educational opportunities. In Zurich, students in primary and lower secondary education are allocated to schools within their residential school districts, which are areas of distinct socioeconomic composition. Permission to attend a school in another district is granted only in exceptional circumstances. Thus, the composition of the student population in school districts (neighborhoods) mirrors the student composition within schools. The cantonal authority is sensitive toward the possible educationally relevant influences of student intake characteristics across school attendance areas and provides additional funding for schools in socially more deprived areas. Social deprivation is measured by the social deprivation index, which is compiled by the Department of Education in Zurich. School districts scoring higher on the social deprivation index are paid more full-time equivalents for teaching.[3] This measure is aimed toward counteracting potentially adverse contextual effects on the learning outcomes of students in socially more deprived areas, as there is no redistribution of students across school attendance areas.

**Sample.** The target population of the Zurich Learning Progress Study included all 11,118 children from the Canton of Zurich, Switzerland, who enrolled in the 2003/04 school year in one of the 650 first grade regular elementary school classes (i.e., excluding schools for children with special needs and schools with mixed-age classes). From this target population, a stratified random sample of 120 classes totaling $N = 2,043$ students was drawn with probabilities proportional to class size. All students within the classrooms were then surveyed. On average, children were $M = 6.95$ ($SD = 0.37$) years old upon entry into elementary school.

[3] https://vsa.zh.ch/internet/bildungsdirektion/vsa/de/personelles/vollzeiteinheitenstellenplan/vze_unterricht.html

There were slightly more boys (50.8%) than girls included in the sample, and 27.6% of the children did not speak German (i.e., the dominant school language) at home.

**Assessment Procedure and Standardized Tests**.

The first assessment was conducted immediately following school enrollment in September 2003, when the children were approximately seven years old. At this measurement point, we tested the students' *initial knowledge* in terms of language (reading skills and vocabulary) and mathematical understanding. These initial assessments consisted of individual oral examinations conducted by trained, prospective elementary school teachers recruited from the Zurich University of Teacher Education. The individual assessments of prior language understanding included testing whether the students were able to name letters, read syllables, words, and sentences, understand written sentences, and describe visualized objects concisely. The individual assessments of mathematical understanding included testing whether students were able to count numbers, name written numbers correctly, recognize sequences of numbers, assign matching numbers based on visual displays, and solve simple addition and subtraction tasks. The trained assessment personnel then distributed scores based on evaluation schemes. The initial language assessment was based on 72 items (scale reliability $\rho = 0.983$), while the initial math assessment included 46 items (scale reliability $\rho = 0.963$). All reliability coefficients were calculated from the intraclass correlations of the estimated unconditional plausible values (Koo & Li, 2016). Further details on the assessment procedure and examples of the test items can be found in Moser and Stamm (2005). The second assessment (around the age of ten years) occurred at the end of the third grade, when *academic performance* in mathematics (M3) and language (L3) was assessed. The third assessment (around the age of thirteen years) in mathematics (M6) and language (L6) occurred at the end of the sixth grade, which is the last year of elementary school. Three years later, a fourth assessment (around the age of sixteen years) in mathematics (M9) and language (L9) was conducted at the end of the ninth grade in lower secondary school, which marks the end of compulsory schooling.[4] Academic performance in mathematics and language (German) from third through ninth grades was assessed by means of standardized written tests developed to reflect the official school curriculum of the Canton of Zurich. All items were designed in collaboration with trained teaching personnel and evaluated by didactics experts with regard to their relevance to the curriculum. All items were pretested and tentatively scaled using probabilistic methods to ensure that levels of item difficulty would cover the entire range of expected student abilities. The tests covered at least four content domains in mathematics (arithmetic, sizes/story problems, proportions, and geometry) and four content domains in German (reading comprehension, vocabulary, language reflection, and revising texts) that were examined on each measurement occasion; additional relevant content domains were therefore only examined in respective school years. All tests were graded by trained research personnel using standardized answer keys. In ninth grade, assessments were conducted based on a multi-matrix design where, for the three different school types, booklets that covered the same curricular content domains but included items of differing difficulty were deployed (see Gonzalez & Rutkowski, 2010). The booklets were linked by link items common to all three test versions. The multi-matrix design has the advantage of more efficiently measuring student abilities by using items located on the difficulty scale close to a student's abilities. Tables 1 and 2 display the content domains covered by the standardized written assessments, the total number of items, and the scale reliability measures. More details on the assessment procedure and examples of the test items can be found in Keller and Moser

[4] There was a fifth survey on occupational outcomes (for more details, see Tomasik, Napolitano, & Moser, in press), but this survey was not the focus of this study.

(2008) for third grade, Angelone and Moser (2011) for sixth grade, and Angelone, Keller, and Moser (2013) for ninth grade.

[INSERT TABLE 1 HERE]

[INSERT TABLE 2 HERE]

The students in the sample attended school in about 56 different school districts. Panel attrition was low, with 80% of the initial sample still participating in the final educational assessment in the ninth grade. Of the 20% of the initial sample that was not administered in the final educational assessment, 12% were non-respondents and 8% had relocated.[5] Students are taught in integrated classrooms up to the lower secondary level, where, in Zurich, early tracking starts. $N$ = 235 students in the sample, corresponding to 12% of the students, pursued the academic track at the lower secondary level.[6]

**Measures.** The tests were scaled according to the probabilistic Rasch model (see Bond & Fox, 2015). The compliance of the items with the model was assessed using a weighted mean square fit statistic (see Wright & Masters, 1982). In addition, items with low item–total correlations were excluded from further consideration. Finally, item characteristic curves were inspected visually. The scaling in first grade was performed independently from that in the other grades and resulted in three subscales, of which we used two (reading competencies and mathematical understanding) to capture initial knowledge that was largely independent of schooling because it was assessed immediately following school enrollment.

[5] We tested for selectivity in sample attrition on the variables: socioeconomic status, initial knowledge, and math and reading performance in third grade. We found no significant or relevant differences in these variables between the "start" and "end" samples.

[6] These students may not attend schools in the same school district as their place of residence (i.e., where they attended primary school).

The scaling in third, sixth, and ninth grades was performed using the common-item nonequivalent groups design (for details, see Kolen & Brennan, 2004) to link the items on the same metric scale. As the three-year increase in academic performance was too steep for direct linking, we administered adapted performance tests in additional calibration samples of students from interjacent grades (i.e., fourth, fifth, seventh, and eighth). The calibration samples comprised approximately 150 students per grade, and the number of link items ranged from approximately 40 to 60, depending on the subject matter and the grade. Taken together, our measures were scaled so as to enable a comparison of academic performance across all three grades on the same metric scale at the interval level of measurement. The test scores in math [M3, M6, M9] and language [L3, L6, L9] ranged from 400 to 1,200, with higher values indicating higher performance. We rescaled these scores to range from 4–12. Initial knowledge is a composite factor and is estimated on the basis of the initial test undertaken by students in the first grade, which assessed their initial knowledge in language and math. We combined these two measures on initial knowledge into one latent factor by equating both unstandardized loadings.

**Contextual variable.** The *social deprivation index* is an index on social deprivation in school attendance areas published by the Department of Education in Zurich for the school year 2005/2006 (the school year of the educational assessment in third grade), which was matched to the students' school attendance areas. For the relevant years of the present study, the social deprivation index was operationalized (applying a principal component analysis) using the following factors: unemployment rates, share of immigrants, mobility, and the share of detached houses across school attendance areas. Three characteristics—the unemployment rate, the share of immigrants, and the share of detached houses—contributed with nearly equal weight to the social deprivation index, while moving mobility contributed with a somewhat lower weight to the social deprivation index. Increased shares of the unemployed, immigrants, and mobility measures increased deprivation (positive correlation), whereas increased shares of detached houses reversely measured lower deprivation (negative correlation). The scale of the social deprivation index ranges from 100 to 120, with higher values indicating higher deprivation. School districts scoring higher on the index are paid more full-time equivalents for teaching. Validation of the social deprivation index as a measure of social deprivation has proven that the index correlates with, for example, aggregate socio-economic status and special educational costs across school attendance areas.[7] For the following analyses, the variable social deprivation index was standardized.

**Control variables**. Gender is a dichotomous variable and was coded “1” for female and “0” for male. The language most often spoken at home at the time of primary school enrollment was obtained from parents’ or children’s reports in first grade, but if this information was not available, it was imputed from reports at subsequent measurement occasions. Here, “1” corresponds with (most often) not speaking the teaching language (German) at home, and “0” corresponds with (most often) speaking the teaching language (German) at home. The social status of students was again a composite factor that was operationalized based on parents’ education and cultural capital in the form of books available at home. Parents reported their highest educational attainment, which was recoded into years of schooling. Furthermore, the children reported the number of books that their family had at home. When this data was not available at the first measurement occasion, it was obtained at subsequent measurement points. A value of “0” on the continuous variables of initial knowledge and social status correspond with the grand mean, and a value of “1” indicates one standard deviation above the grand mean.

**Analyses**. In order to estimate intra-individual patterns of academic performance from the third through ninth grades, we utilized latent growth curve modelling. A latent growth

[7] See footnote 3.

curve analysis is a structural equation technique for modelling change over time based on longitudinal data. We first fitted two unconditional growth curves for the domains of math and language based on the standardized test scores from follow-up assessments of the students in the sample (Figure 1). These unconditional growth curves allowed us to assess the average development of math and language performance across grades. The estimated latent intercepts represent average initial math and language performance in third grade, and the latent slope parameters represent the average increase in math and language performance from the third through ninth grades (Figure 2). The variances of the latent growth parameters indicate whether there is inter-individual variation in the initial math and language performances as well as in the rate of their development (see Bollen & Curran, 2006; Byrne, 2012).

As this study was focused on differential academic performances across students and school districts in which the data was of a hierarchical structure and students attended schools nested within the school districts pertaining to their residences, the growth curves were modelled in a multilevel setting. Multilevel modeling is especially suited for investigating contextual effects because it allows researchers to disentangle contextual effects from the individual effects of students' background characteristics (Rumberger & Palardy, 2005). Based on multilevel growth curve models (Figure 3), we then assessed whether and how students' background characteristics and the context of school districts affected academic performance across students and attendance areas.

The employed growth curve multilevel models (see Figure 3) can also be thought of as three-level models: at the first level, growth in math and reading test scores nested within students was modelled; at the second level, the effects of student-level background characteristics on the growth parameters were modelled; at the third level, the effects of the school district variables were modelled (social deprivation index) on the mean performance between school districts, for which the effects of the individual-level background characteristics of the students were adjusted. Following Rumberger and Palardys' (2005) notations, we depicted the multilevel growth curve model employed with:

$Y_{tij} = \pi_{0ij} + \pi_{1ij} a_t + e_{tij}$, where [1]

$\pi_{0ij} = \beta_{00j} + \beta_{01j} X_{1ij} + \cdots + \beta_{0pj} X_{pij} + r_{0ij}$, [2.1]

$\pi_{1ij} = \beta_{10j} + \beta_{11j} X_{1ij} + \cdots + \beta_{1pj} X_{pij} + r_{1ij}$, [2.2]

$\beta_{00j} = \gamma_{000} + \gamma_{001} W_{1j} + u_{00j}$, and [3.1]

$\beta_{10j} = \gamma_{100} + \gamma_{101} W_{1j} + u_{10j}$. [3.2]

At the first level [1], $Y_{tij}$ represents the observed test scores in either math or language in grade *t* of pupil *i* attending school in school district $j$. The intercept parameter $\pi_{0ij}$ represents the score of pupil *i* in third grade. The slope parameter $\pi_{1ij}$ represents pupil *i*'s gain in performance across the third through ninth grades. Time *t* is represented by $a_t$, which is specified as a vector of three values (0, *x*, and 1) that correspond with performance in the third, sixth, and ninth grades. Since growth in educational performance across the observed grades was non-linear, the parameter for the sixth grade (noted above as *x*) was estimated freely to allow for non-linear performance gains.[8] At the second level [2.1, 2.2], $\pi_{0ij}$ and $\pi_{1ij}$ were regressed on individual-level characteristics $X_{pij}$, where $\beta_{00j}$ and $\beta_{10j}$ were the intercept parameters representing the adjusted mean test score performance in third grade ($\beta_{00j}$) in school district $j$ and the adjusted mean growth in academic performance ($\beta_{10j}$) in school district $j$. The $\beta_{0pj}$ are the estimated effects of the individual-level background characteristics

[8] We conducted corrected chi-square-difference tests to compare the linear and non-linear growth curve models. The linear growth curves fitted the data significantly less closely. The corrected chi-square differences were as follows: language: $\Delta\chi^2_{[1]}$ = 7.2; math: $\Delta\chi^2_{[1]}$ = 84.0

$X_{pij}$ (e.g., gender, socio-economic status, migrant background, and initial knowledge) on performance in third grade, whereas the $\beta_{1pj}$ are estimated effects of the individual-level background characteristics on growth rates. At the third level [3.1, 3.2], the adjusted school district mean scores in performance in third grade, which was $\beta_{00j}$, and the adjusted mean growth rates at the school district level, which was $\beta_{10j}$, were regressed on the school district covariate $W_{1j}$ (e.g., social deprivation index); thus, $\gamma_{001}$ and $\gamma_{101}$ represent the estimated effects of social deprivation at the school district level. The variables $e_{tij}$, $r_{0,1ij}$, and $u_{0,10j}$ represent error terms at the respective levels.

Multilevel growth-curve modeling was executed using MPlus and was based on full information maximum likelihood (FIML; Enders & Bandalos, 2001). We considered the complex survey design of the sample by using the PSU (primary sampling units) and strata (sample stratification) variables.[9]

## Results

In the following results sections, we first introduce our findings on social disparities in the initial knowledge of first grade students. We then show the general evolvement of math and language performance of the students between the third and ninth grades in compulsory education and display goodness-of-fit indices for the estimated baseline growth curve models. Next, the growth curves of academic performance are portrayed in a multilevel setting, and individual- and school district-level effects are presented.

### Individual- and Contextual-Level Effects on Initial Knowledge

[9] There are some pitfalls and ambiguities in using survey weights within multilevel analyses (see, e.g., Asparouhov, 2006). The models reported in Tables 2 and 3 were fitted without using survey weights. As the student-level weight was (approximately) “1” for all students (within selected classrooms, everybody was surveyed), we re-estimated the models, including an approximate survey weight at the second level only, which was rescaled to the sample size. The main findings remained the same.

Upon modelling initial knowledge (which was assessed within the very first weeks upon entry into primary school) in a multilevel context, we found—unsurprisingly—that students' social backgrounds significantly predicted initial knowledge. Higher social status was linked to higher initial knowledge upon entry into primary school. Thus, children from lower social backgrounds were disadvantaged regarding initial knowledge in math and language at the outset. Furthermore, students who most often did not speak the teaching language (German) at home entered primary school with lower initial knowledge, and female students had, on average, lower initial knowledge. The gender difference regarding the disadvantage of girls surfaced because girls scored significantly lower on the math section of the initial assessment than boys, whereas they scored slightly—although not significantly—higher than boys on the language section. We further tested for significant interaction between gender and the social status of students. The findings indicate that social status did not moderate the effect of gender on initial knowledge. Focusing on the level of school districts, we found, while controlling for individual-level covariates such as gender, immigrant status, and social background, the initial knowledge of students did not significantly vary across school districts. Thus, upon adjusting for individual-level predictors of initial knowledge, no context-level variation remained to be explained by the social deprivation index.

[INSERT TABLE 3 HERE]

**Describing Academic Performance Trajectories**

In terms of academic performance development from the third through ninth grades, we found that, according to the goodness-of-fit statistics (*Language:* $\chi^2 = 2.2$, df = 3, CFI = 1.00, TLI =1.00, RMSEA = 0.00, p-close = 0.99, SRMR = 0.045, *Math:* $\chi^2 = 2.6$, df = 3, CFI = 1.00, TLI =1.00, RMSEA = 0.00, p-close = 0.99, SRMR = 0.068) (see Figure 1), the fitted unconditional latent growth curve models matched the data sufficiently. The latent intercept for language did not correlate with the latent slope for language, while the same held true for math. This means students with greater initial knowledge did not experience steeper (or slower) increases in academic performance in the respective domain. Thus, starting off at a higher level in the third grade did not predict the rate of progress up to the ninth grade.

[INSERT FIGURE 1 HERE]

Furthermore, the results demonstrate similarities in growth across the domains of language and math (see Figure 2 and Table 4). The growth curves are non-linear; the steepest gain in academic performance was indicated during primary education (grades three–six), while growth flattened during lower secondary education (grades six–nine). This corresponds with previous findings showing the average academic performance trajectory to be one of rapid growth during elementary education, followed by gradually declining gains during later school years (Bloom, Hill, Black, & Lipsey, 2008; Cameron et al., 2015).

[INSERT TABLE 4 HERE]

[INSERT FIGURE 2 HERE]

The variances of the latent intercept and slope parameters were all significant. This means that there were inter-individual differences in third grade academic performance and growth rates across the student population. These differences in academic performance may be further explained by differential student background characteristics.

**Individual and Contextual Effects on Academic Performance Trajectories**

Focusing on the latent growth curves in the multilevel setting, we found further variations in the latent growth parameters across school districts. There was significant variance in third grade language and math performance as well as significant variance regarding improvement in math performance from grades three to nine across school districts. Thus, the mean academic performance in third grade differed across school districts for both domains. In addition, growth rates varied across school districts for math. For language, gains in performance were similar across school districts.

[INSERT FIGURE 3 HERE]

Partitioning the variance of the growth parameters into variance at the student and school district levels, we found that 17% of the variance in third grade language and 15% of the variance in growth rates in language performance (though the total amount was not significant) were between the school districts (see Figure 4). For math, 13% of the variance in third grade math performance and 36% of the variance in growth rates were between school districts (see Figure 5). More than half of this variance in the growth parameters at the school district level can be explained by differential student intake characteristics across school districts.

[INSERT FIGURE 4 HERE]

[INSERT FIGURE 5 HERE]

Focusing first on the *individual-level effects* (Table 5), the results show a positive association between female gender and language performance in third grade (positive intercept effect), while the negative effect of female gender on the slope parameter of language indicates somewhat slower growth in language performance for female compared to male students (significant at $p \leq .10$). Thus, female students scored higher on language in third grade, but male students seemed to catch up over the observed school years, although not fully. Turning to math performance, female students started with slightly lower performance in math in the third grade (negative, but not a significant intercept effect) and experienced somewhat steeper growth in math performance. Controlling for the variables included in the model, students who (most often) spoke a foreign language at home started off with lower knowledge in language and math in third grade (negative intercept effects). The non-significant effects on the slope parameters further indicate that students who spoke a foreign language at home did not catch up over the school years with students who spoke German at home. However, the non-significant slope effects also suggest a non-widening gap in math and language performance between students who spoke German and those who did not speak German at home. The results further suggest that students with greater initial knowledge, which encompasses pre-school knowledge in language and math, still had some advantage in third grade; these students scored higher on both standardized math and language tests. The small negative effect in the language domain and the non-significant effect in the math domain on the slope parameters show no widening gap compared to other students who started school with lower levels of initial knowledge. Concerning the domain of language, students with more initial knowledge showed a somewhat lower growth in language performance (significant at $p \leq .10$). Altogether, students with more initial knowledge upon entry into primary education seemed to maintain their lead, although they did not experience steeper gains. Turning to the students' social backgrounds, the story can be described as one of cumulative (dis)advantages. Students from higher social backgrounds achieved higher scores in math and language in the third grade despite controlling for heritage language and initial knowledge. In addition, the positive and significant effects on the slope parameters show significantly steeper increases in both domains from grades three to nine for students of a higher social standing.

Focusing on the *school-context level* (Table 5), where we investigated whether school districts matter over and beyond differences in student characteristics and initial knowledge, we found significant variance in average school district outcomes for both math and language in the third grade as well as significant variance for average gains in math performance across school districts. Introducing the social deprivation index as a measure for social deprivation at the level of school attendance areas into the analysis, we found that, when adjusted for differential student intake characteristics, the mean performance of students attending schools in more disadvantaged districts (higher social deprivation index) was slightly lower compared to the mean outcomes of students in more privileged school districts (small, negative, and significant intercept effects). In other words, when controlling for differential student intake characteristics regarding initial knowledge and social background across districts, social deprivation in school attendance areas still coincided with a lower mean performance. The non-significant effects on the slope parameters indicate that the gap was not widening from grades three to nine on account of the social deprivation of school attendance areas. Yet, this gap across attendance areas is also not closing over the later school years. Even though we introduced into the analysis the social deprivation index as a policy-relevant measure for social deprivation in school attendance areas, some residual variance persisted in the mean performance across school districts in math in the third grade, which could be explained by other factors. The correlation matrix displaying correlations between test scores, social backgrounds, and the social deprivation index can be found in the Appendix.

We further tested whether the effects of the individual-level covariates, such as the effects of social status or initial knowledge, and the language most often spoken at home varied across school districts (random slopes). The results suggest that the effects were the same across school districts (no cross-level interaction). Thus, social status led to similar cumulative advantages on the development of academic performance during school regardless of the Zurich district in which the students attended school. The same held true for the effects on initial academic performance regarding initial knowledge and the language spoken at home.

[INSERT TABLE 5 HERE]

For illustrative purposes, examples for widening SES differences in performance in math and language are shown in Figures 6 and 7. The examples show latent growth curve trajectories in language and math performance for boys who entered school at average initial knowledge and whose heritage language corresponds to the school language. Low and high SES denote the extremes of two standard deviations above or below the mean SES. Similarly, a low and high social deprivation index (SDI) of school districts again illustrates the extremes of two standard deviations above or below the mean social deprivation of school districts. For girls, SES effects on trajectories are the same. Girls generally begin at marginally lower levels in math compared to boys, and then catch up as they experience a slightly steeper increase in performance development.

[INSERT FIGURE 6 HERE]

[INSERT FIGURE 7 HERE]

## Discussion

This study employed latent growth curve modeling to examine trajectories of academic performance in the context of social inequality at the levels of individual students and school districts. It drew on a stratified random sample of school classes in Zurich, Switzerland, from which the students repeatedly participated in standardized educational assessments during primary and lower secondary education. First, the findings support non-linear growth trajectories in academic performance development for both math and language competences, showing more rapid growth during primary compared to lower secondary education. This is consistent with previous research on the evolvement of academic performance in the U.S. (e.g., Bloom et al., 2008; Cameron et al., 2015).

More importantly, however, the findings suggest cumulative disadvantages in the development of academic performance in the domains of math and language for students from lower socioeconomic backgrounds. Students from lower socioeconomic backgrounds enter school with lower levels of initial knowledge in math and language. Thus, they experience a disadvantage from the very beginning of their school career. Controlling for gender, heritage language, and initial knowledge, students of lower social backgrounds achieved lower performance levels in third grade of primary school and additionally gained less knowledge up to the end of lower secondary education. Corroborating previous research (e.g., Angelone & Ramseier, 2012; Caro et al., 2009; Kieffer, 2012), we find a socially stratified widening gap in academic performance over the entire span of compulsory schooling in Switzerland. Hence, schools are not successful in equalizing social performance gradients even when initial knowledge at school entry is accounted for. The finding of cumulative advantage in academic performance development for higher SES children, however, does not prove that schools exacerbate social inequalities in academic performance, although schools, in their rewards and recognitions, may be socially selective (Caro et al., 2009; Downey et al., 2004). The reasons for the socially stratified gains in academic performance also reside in factors lying outside the school, such as the family, other institutions, and social networks, as learning and the development of competences conducive to learning in school do not only take place on site at schools (see, e.g., Downey & Condron, 2016). The home environment may, in a continuing fashion, affect cognitive gains. As the mastery of more advanced topics builds on simpler forms (Cameron et al., 2009), accelerated performance gains for students from higher socioeconomic backgrounds may perpetuate. Social gradients in academic performance have, for example, been proven to widen over the summer break, giving higher SES students a head start in the new school year (e.g., Downey et al., 2004). Genetically informed research also points toward increasing heritability of cognitive ability with age (Haworth & Davis, 2014). Haworth and Davis (2014) argue that active gene–environment correlations may provide one explanation, where students of higher cognitive ability may, at higher levels, seek cognitive challenges that, in turn, manifest in accumulated environmental exposure to cognitively stimulating interactions with peers and materials. Early tracking that, in Zurich, begins in lower secondary education, can also exacerbate socially stratified learning progress as differential curricula expose children to more or less challenging educational material and objectives (Condron, 2008). Separate (and additional) effects of curriculum differentiation on increases in academic performance at the lower secondary level were, however, not the focus of this paper.

Apart from individual resources through familial background, which determine educational performance development, the literature on contextual effects has repeatedly pointed to the educationally relevant effects of the social composition of the neighborhood and—in an interrelated context—the composition of the student body in schools (e.g., Aikens & Barbarin, 2008; Ewijk & Sleegers, 2010; Gibbons, 2002; Kieffer, 2012; Rumberger & Palardy, 2005).

In Zurich, students are allocated to schools within their school attendance areas such that social differences in the composition of neighborhoods are mirrored in the differential student intake characteristics of schools. Peer influences that support or oppose a pro-school normative learning environment, the collective socialization and networking of parents, differential teacher expectations, instructional practices, and the relations of parents with local institutions may all affect the academic performance development of children over and beyond their individual preconditions (see, e.g., Coleman, 1968; Galster, 2012; Jencks & Mayer, 1990). Thus, school attendance areas that are socially stratified milieus may represent differential social learning environments. The cantonal authority of Zurich acknowledges educationally relevant influences of student intake characteristics and distributes additional funding to schools in socially more deprived school attendance areas based on the social deprivation index measure. Employing the growth curve analysis in a multilevel setting, we further investigated the contextual effects of school attendance areas by means of the policy-relevant social deprivation index.

In line with previous research, we find that the lion's share of variance in the growth trajectories of academic performance during compulsory schooling is at the individual level rather than the school district level. It is more about one's own familial background and individual preconditions than the school attendance area of residence that matters for growth in academic performance. Our findings, however, suggest some differences in academic performance across school districts, which persisted despite the redistributive measure of additional funding to schools in socially more deprived school attendance areas. While there were no mean differences in the students' initial knowledge across attendance areas, when adjusting for individual-level effects, socially more deprived areas achieved lower scores in math and language in the third grade. Thus, during the first years of primary schooling, there seemed to be some differential progress across school attendance areas, which is in line with Aikens and Barbarin's findings (2008) that point to the importance of schools in the initial phase of rapid performance growth from kindergarten to the first few years in elementary school. However, the gaps in the mean performance across areas did not increase over the remaining later years of compulsory education. As another interesting result of this study, we found that the share of variance in gains in math attributable to the level of school attendance areas was much larger than the respective between-districts share of variance in growth in language. While gains in language performance may, to a larger extent, be explained by inter-individual differences in social backgrounds and heritage language at the familial level, gains in math performance may be comparatively more connected to learning in school.

## Limitations

Longitudinal studies allow for the measurement of change in individual development over the long term. To follow up with individual students, the costs of pretesting instruments and conducting high-standard assessments are usually very high, such that focusing on multiple cohorts is often not an option. This drawback—due to the longitudinal nature of the data—indicates that the first year of observation for a single cohort under consideration dates back quite a few years; furthermore, we cannot measure change over time across cohorts. Hence, single cohort studies are limited because cohort-specific effects cannot be controlled for; we cannot evaluate whether or how much social background effects may have been subject to change across cohorts and time. This issue remains answerable for future research that adopts multi-cohort longitudinal designs. Furthermore, it remains an open question of whether cantonal authorities' funding for more socially deprived areas counteracts and prevents larger school district-level differences. At the lower-secondary level, school districts can differ from the school districts in primary education, as small school districts for primary education sometimes form combined districts at the lower secondary level that cannot be fully accounted for by our analyses. In addition, we should note that omitting or inaccurately measuring students' social backgrounds may upwardly bias estimated contextual effects because measures of the social composition of school attendance areas may be a proxy for unmeasured individual social background characteristics (Jencks & Mayer, 1990). This is a well-known caveat of investigating contextual effects based on observational survey data. Another study limitation is that causal mechanisms such as peer influences, collective socialization, or school processes that are assumed to underlie the influence of social contexts on educational performance cannot be separated. These mechanisms—as with many previous studies—remain a "black box" and should be researched more carefully in the future. Moreover, several opposing contextual effects may exist simultaneously, meriting further attention. Even though lower-achieving students may benefit from cognitive skill development by attending school with higher achievers, they may simultaneously be disadvantaged by social comparison processes in terms of their academic self-concepts (Montt, 2012). On one hand, it is assumed that the educational aspirations of classmates spill over, while on the other, social contrast (Rosenqvist, 2018) along with big-fish-little-pond effects (Marsh, 1987) may shape the expectations and educational choices of lower-achieving students quite differently. Furthermore, teachers evaluate their students within the social reference framework of the classroom. A lower-achieving student may be given a worse grade in a high-achieving class compared to the grade he or she would have received in a lower-achieving class (Marsh, 1987). As grades legitimize the allocation of students to different school tracks, they can be highly relevant for future educational careers. Thus, the technical development of academic performance during schooling should not be the only benchmark by which to evaluate educationally relevant contextual effects.

Last, but certainly not least, one should note that attempts at isolating the effects of the family environments from those of extra-familial social learning environments fall short, to some extent, because contextual effects—having become an integral part in the intergenerational transmission of advantage and disadvantage—may extend over generations of families (Sharkey & Faber, 2014).

## Conclusion

By utilizing long-term longitudinal data that allowed us to monitor academic performance over the years of compulsory schooling, we demonstrated that academic performance (baseline and gains) is socially stratified. The introduced multilevel context suggests that, before school starts, there are little or no contextual effects of school attendance areas on initial knowledge; rather, the individual families with which children grow up matter more for the latter's development of initial knowledge. When school starts and children attend schools of different social compositions, however, some discrepancies in performance become apparent particularly during the first years of schooling. Future research on contextual effects might be interested in showing how higher initial gains in academic performance in well-off school attendance areas at the very early stages of elementary schooling might, in parallel with peer influences and instructional practices, relate to the presumably high parental school engagement of middle- and upper-class families when children are young. Possessing knowledge on beneficial parental school involvement in privileged districts as well as knowing how this may be supported in less privileged districts may help counteract contextual effects.

## Research Ethics

The Institute of Educational Evaluation, University of Zurich, was mandated with the collection of data for monitoring academic performance over compulsory schooling by cantonal authorities (Department of Education in Zurich). As the contractor, the Institute of Educational Evaluation signed and committed to strictly obeying the cantonal law and best practices to assure data confidentiality.

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Table 1

*Language Assessments*

| Grade 3 (L3) | Grade 6 (L6) | Grade 9 (L9) |
|---|---|---|
| Reading comprehension | Reading comprehension | Reading comprehension |
| Revising texts | Revising texts | Revising texts |
| Language reflection: | Language reflection: | Language reflection: |
| Spelling | Spelling | Spelling |
| Grammar | Grammar | Grammar |
| Writing texts | | |
| Appropriate wording | Vocabulary | |
| Total: 115 items | Total: 326 items | Total: 184 items |
| Scale reliability = 0.983 | Scale reliability = 0.981 | Scale reliability = 0.987 |

Table 2

*Mathematics Assessments*

| Third grade (M3) | Sixth grade (M6) | Ninth grade (M9) |
|---|---|---|
| Operations/Algebra | Operations/Algebra | Operations/Algebra |
| Sizes | Sizes/story problems | Sizes/story problems |
| Geometry | Proportions | Proportions |
| | Geometry | Geometry |
| Quantities | | |
| Number ranges | Fractions | Equations and inequalities |
| Notations for numbers | Problem solving | Functions |
| | | |
| Total: 167 items | Total: 179 items | Total: 85 items |
| Scale reliability = 0.986 | Scale reliability = 0.986 | Scale reliability = 0.982 |

Table 3

*Explaining Inter-Individual Differences in Initial Knowledge*

| | ***Initial knowledge*** | |
|---|---|---|
| n = 1568 | ***Effect*** | ***CI [95%]*** |
| *Intercept* | 0.22 | [0.13,0.32] |
| ***Individual Level*** | | |
| Gender (female) | **-0.17**** | [-0.27,-0.06] |
| Language (NOT German) | **-0.18**** | [-0.32,-0.05] |
| SES | **0.23***** | [0.17,0.29] |
| ***School District Level*** | | |
| Social deprivation index | 0.01 | [-0.06,0.07] |
| ***Residual Variances*** | | |
| $\sigma^2_{(within)}$ | 0.88*** | [0.81,0.95] |
| $\sigma^2_{(between)}$ | 0.00 | [-0.04,0.04] |

(*) p ≤ 0.1 * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001 CI = confidence interval

Table 4

*Average Development of Academic Performance*

| Mean scores | 3rd grade | 6th grade | 9th grade |
|---|---|---|---|
| Language | 4.97 | 7.76 | 8.80 |
| Math | 4.91 | 8.74 | 9.30 |

Table 5

*Explaining Differential Growth in Academic Performance*

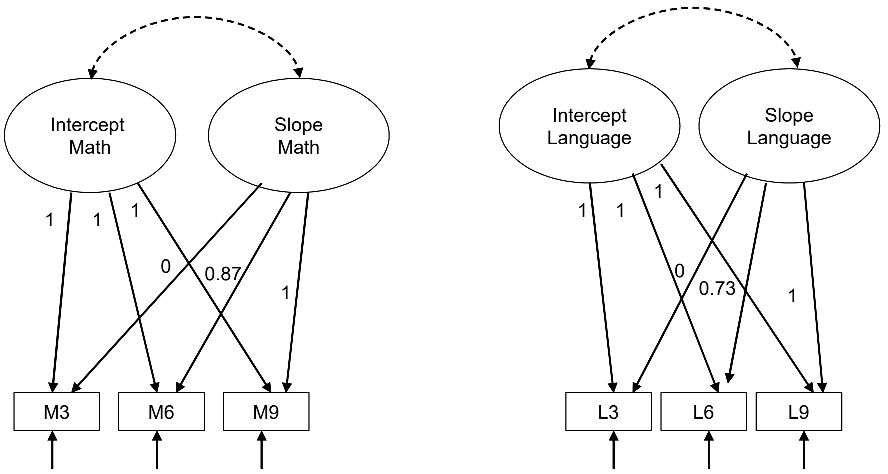
| | ***Language*** | | ***Math*** | |
|---|---|---|---|---|
| | ***Effect*** | ***CI [95%]*** | ***Effect*** | ***CI [95%]*** |
| *Intercept (Intercept)* | 4.84 | [4.76,4.96] | 5.05 | [4.95,5.16] |
| *Intercept (Slope)* | 3.86 | [3.76,3.94] | 4.30 | [4.22,4.38] |
| ***Individual Level*** | | | | |
| ***Intercept Parameter ON*** | | | | |
| Gender (female) | **0.52*****| [0.45,0.60] | -0.08 | [-0.18,0.03] |
| Language (NOT German) | **-0.28***** | [-0.40,-0.16] | **-0.15***** | [-0.23,-0.07] |
| Initial knowledge | **0.45***** | [0.40,0.49] | **0.47***** | [0.43,0.51] |
| SES | **0.22***** | [0.17,0.26] | **0.16***** | [0.09,0.22] |
| ***Slope Parameter ON*** | | | | |
| Gender (female) | **-0.11(*)** | [-0.21,-0.00] | 0.10** | [0.03,0.17] |
| Language (NOT German) | 0.00 | [-0.10,0.10] | 0.04 | [-0.07, 0.14] |
| Initial knowledge | **-0.05(*)** | [-0.09,0.00] | -0.01 | [-0.07,0.04] |
| SES | **0.11***** | [0.07,0.16] | **0.15***** | [0.09,0.21] |
| ***School District Level*** | | | | |
| ***Intercept Parameter ON*** | | | | |
| Social Deprivation Index | **-0.13*** | [-0.26,-0.01] | **-0.12*** | [-0.21,-0.02] |
| ***Slope Parameter ON*** | | | | |
| Social Deprivation Index | 0.02 | [-0.06,0.10] | -0.05 | [-0.17,0.07] |
| ***Residual Variances*** | | | | |
| $\sigma^2_{Intercept\ (within)}$ | 0.28*** | [0.25,0.31] | 0.32*** | [0.27,0.35] |
| $\sigma^2_{Slope\ (within)}$ | 0.13*** | [0.07,0.19] | 0.15*** | [0.10,0.19] |
| $\sigma^2_{Intercept\ (between)}$ | 0.02 | [-0.01,0.04] | 0.03** | [0.01,0.05] |
| $\sigma^2_{Slope\ (between)}$ | 0.00 | [0.00,0.00] | 0.01 | [-0.01,0.04] |

(*) $p \leq 0.1$ * $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$, $n_{language}$=1567, $n_{math}$=1566, CI = confidence interval

Note: The main results are the same if the model is re-estimated, including five plausible values for math and language scores (hence, taking into account measurement errors).

Figure 1

*Unconditional Growth Curves for Math and Language Performance*




Language: $\chi^2 = 5.0$, df = 3, CFI= 1.00, TLI =1.00, RMSEA = 0.02, p-close = 0.96, SRMR = 0.044, n = 1780

Math: $\chi^2 = 3.1$, df = 3, CFI = 1.00, TLI =1.00, RMSEA= 0.00, p-close = 0.99, SRMR = 0.062, n = 1778

Note: Loading on the latent slope parameter for sixth grade was estimated freely and then fixed for further analysis.

Figure 2

*Mean Growth in Math and Language Performance*

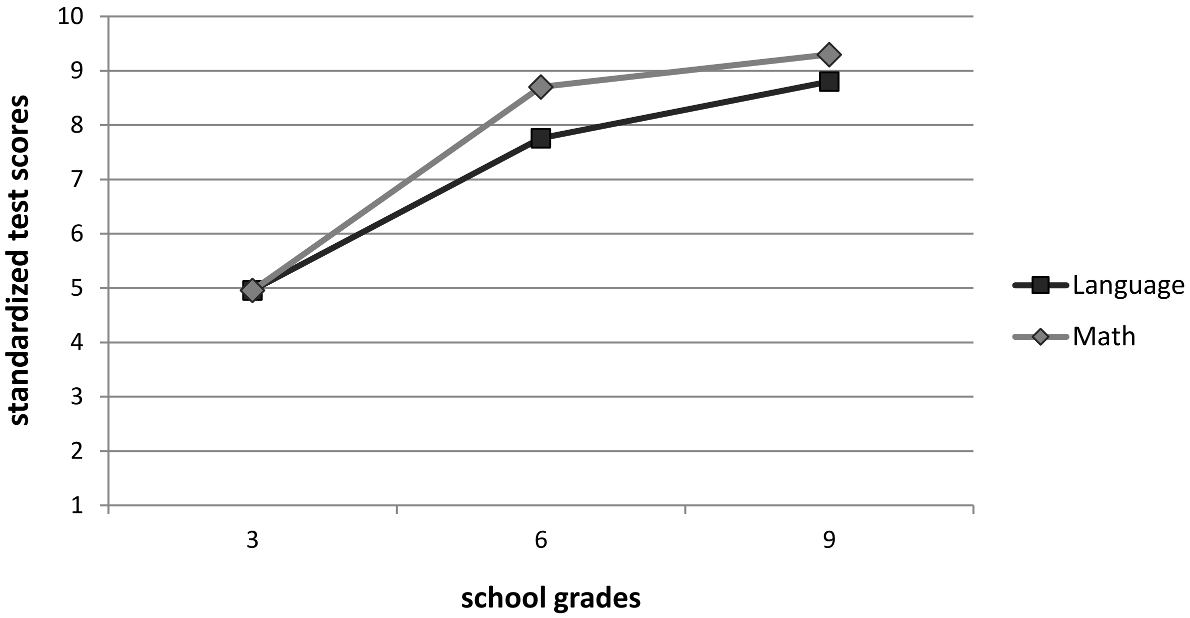
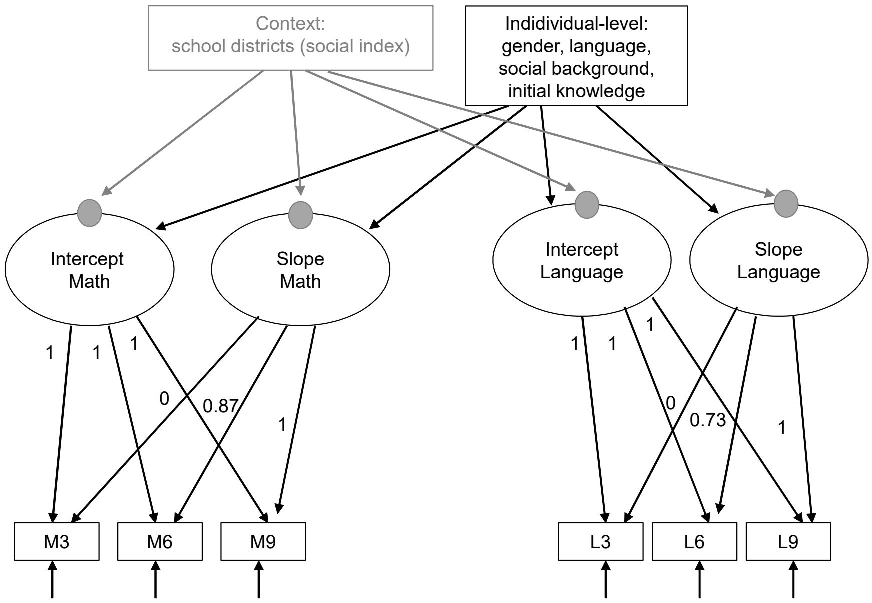


Figure 3

*Conditional Multilevel Growth Curves for Math and Language Performance*




Language: $\chi^2 = 4.85$, df =12, CFI = 1.00, TLI = 1.00, RMSEA = 0.00, SRMR (within) = 0.005, SRMR (between) = 0.015, n = 1567

Math: $\chi^2 = 0.20$, df = 12, CFI = 1.00, TLI = 1.5, RMSEA = 0.00, SRMR (within) = 0.004, SRMR (between) = 0.037, n = 1566

Figure 4

*Variance Partitioning: Academic Performance in Language*

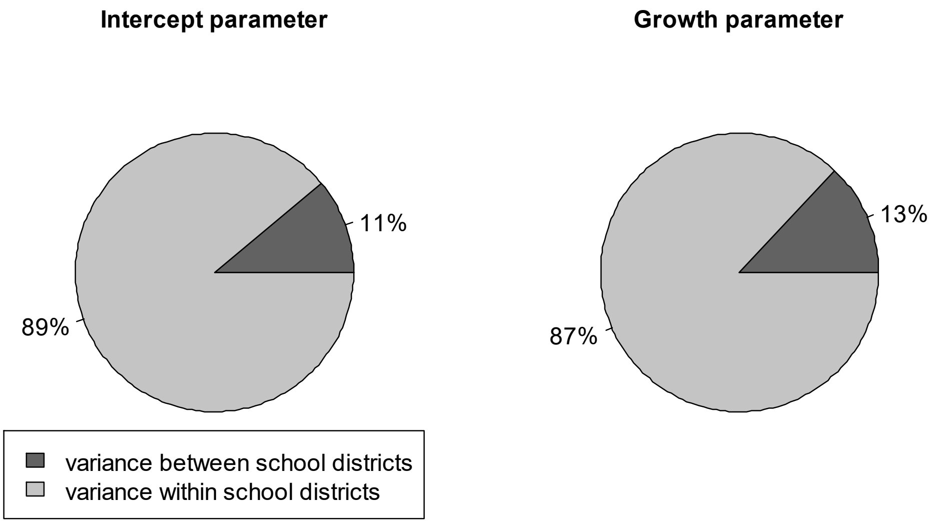


Figure 5

*Variance Partitioning: Academic Performance in Mathematics*

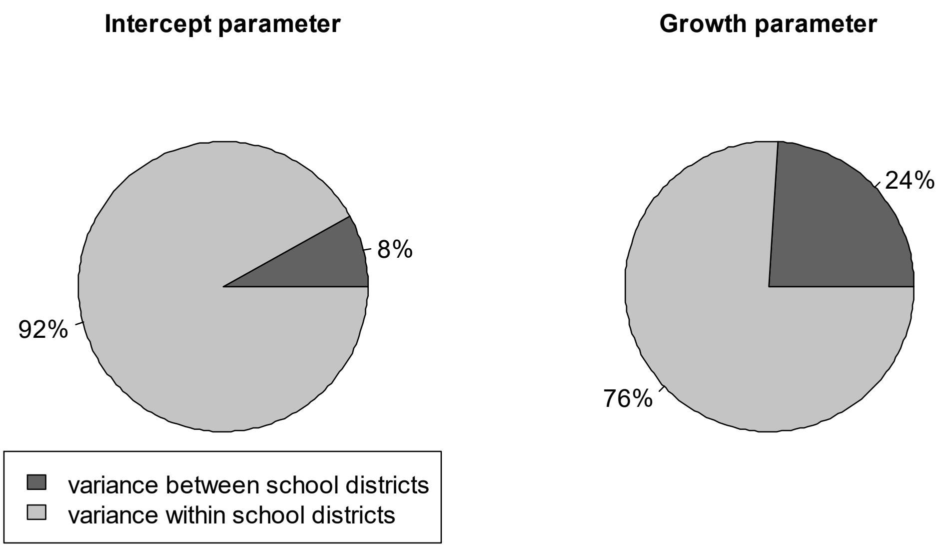
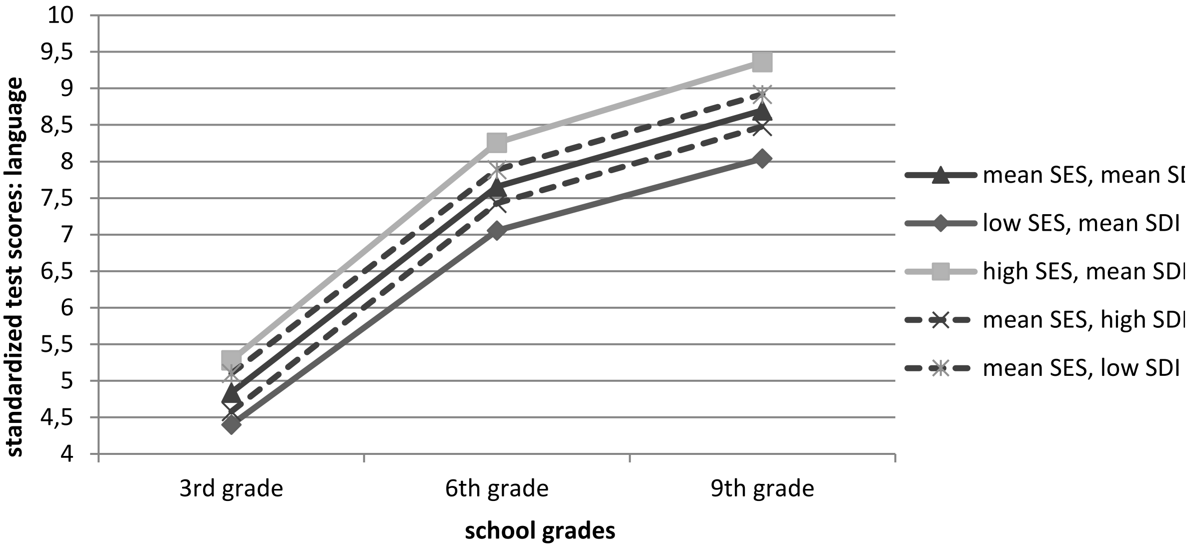


Figure 6

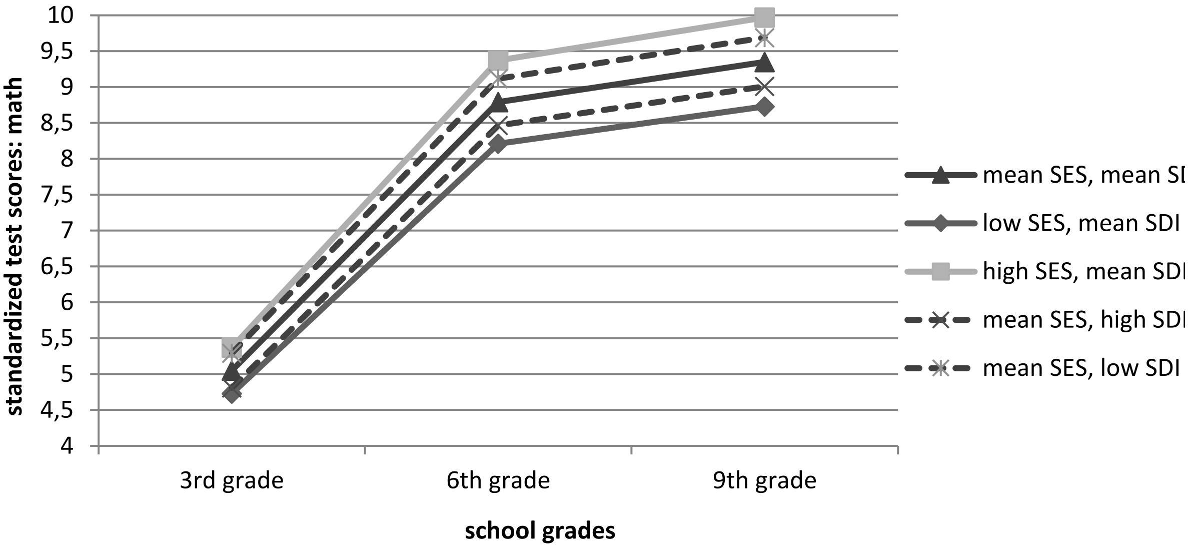
*Social Disparities in Language Performance Across Compulsory Education*




SES = socioeconomic status, SDI = social deprivation index of school district

Figure 7

*Social Disparities in Math Performance Across Compulsory Education*




SES = socioeconomic status, SDI = social deprivation index of school district

## Appendix

Correlations for the Test Scores, SES, and Social Deprivation Index in the Zurich Learning Progress Study

| | I1 | M3 | M6 | M9 | L3 | L6 | L9 | SES |
|---|---|---|---|---|---|---|---|---|
| I1 | -- | | | | | | | |
| M3 | 0.48 | -- | | | | | | |
| M6 | 0.49 | 0.61 | -- | | | | | |
| M9 | 0.44 | 0.59 | 0.69 | -- | | | | |
| L3 | 0.47 | 0.60 | 0.55 | 0.52 | -- | | | |
| L6 | 0.46 | 0.51 | 0.66 | 0.61 | 0.68 | -- | | |
| L9 | 0.41 | 0.49 | 0.61 | 0.67 | 0.64 | 0.72 | -- | |
| SES | 0.24 | 0.29 | 0.38 | 0.39 | 0.37 | 0.45 | 0.43 | -- |
| SDI | -0.07 | -0.18 | -0.18 | -0.21 | -0.21 | -0.23 | -0.19 | -0.20 |

M = math, L = language, I1 = initial knowledge, [3,6,9] = school grades of assessments, SES = social background, SDI = social deprivation index of school districts